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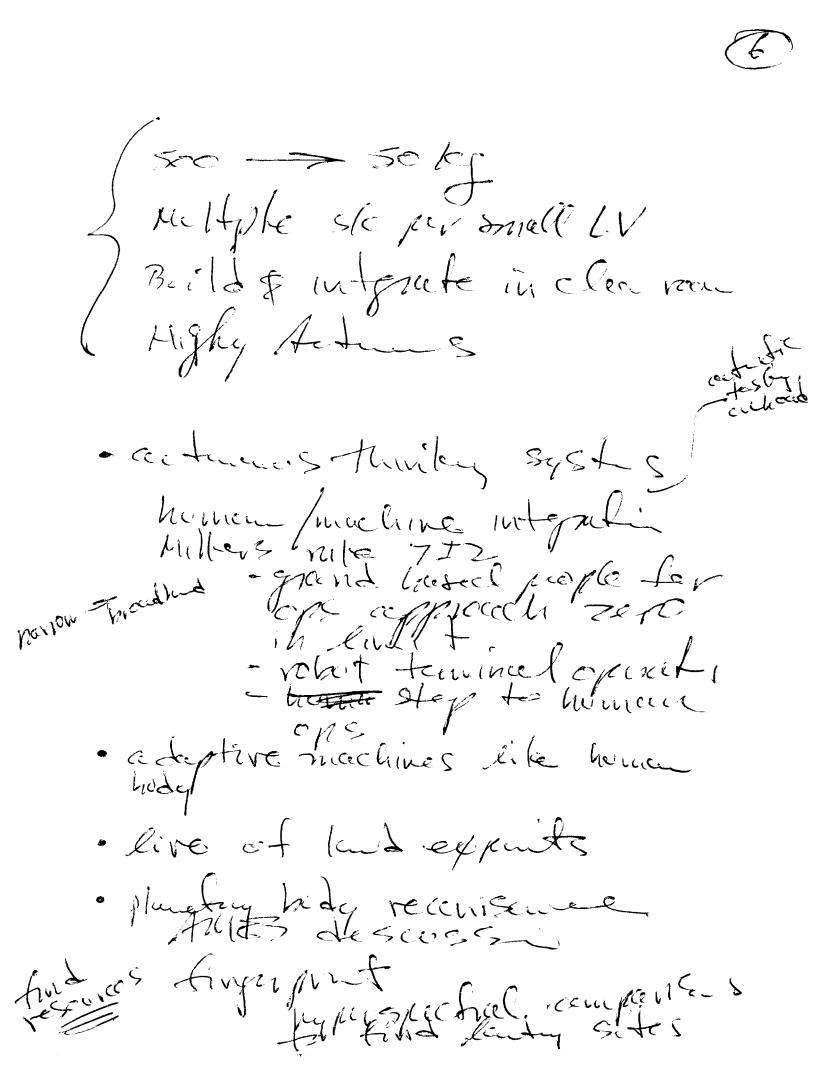
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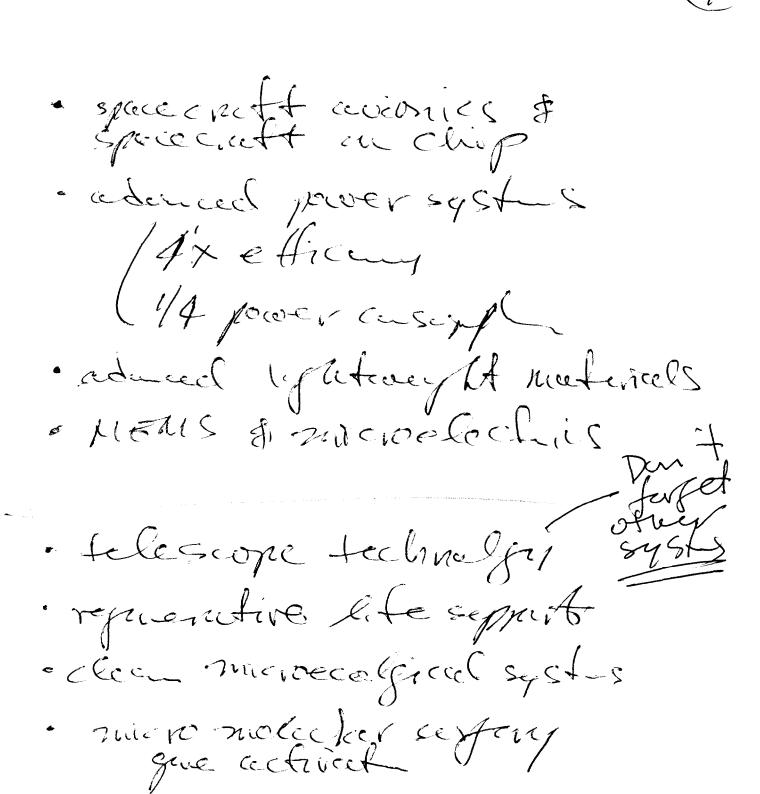
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## Talking Points Division for Planetary Sciences, American Astronomical Society Nov. 1, 1994

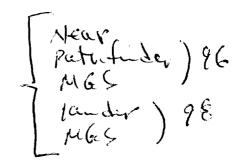
- Two main themes tonight:
  - --NASA is committed to continuing great planetary science missions.
  - --Fiscal realities have changed. Money available for planetary science will be far below the levels we're used to. To do great science, we have to have a revolution—a revolution that will let us do more with less.
- The nation needs smaller, lighter, cheaper initiatives. Goal is not simply to spend less money and complete projects more quickly. The goal is to do all that and have the end result be better science.
- Doing things cheaper and more quickly is not a pie-in-the-sky dream. It's a must. NASA, and every other Federal Agency, is facing severe budget pressures -- every dollar under intense scrutiny.
  - --Since 1991, Congress has capped all discretionary spending at the mid-\$540 billion range, and that will last through 1998.

- --NASA has taken a 30% cut in two years, and looking at a flat budget over the next five years. That means we'll lose between \$400 and \$500 million dollars in buying power a year.
- Still, we are maintaining our commitment to science. NASA science programs have increased from \$3.3 billion in FY 94 to \$3.5 billion in FY 95, the highest level ever.

## Past, present, future

- Typical old-style Battlestar Galactica planetary mission:
  - --\$1 billion + cost, mass up to 2000 kg.
  - -- Dedicated Titan IV class ELV or shuttle
  - --Systems behind state-of-the-art due to long development times
  - --Large ground-based infrastructure needed for assembly and launch prep
  - --Labor-intensive mission operations
  - -- Launch one mission every 2-3 years
- Disaster for planetary science if we continued this approach.
- -- The budget will not support this type of mission. Best we could hope for is some kind of flyby mission.

• Where we are now: in our planetary program, we now have 5 new missions planned.



- Typical Discovery class mission 1995-2000
  - --\$150 million (or less), \$35 million operations
  - -- Mass = hundreds kg
  - --Dedicated Delta (or smaller) ELV
  - --36 months from award thru postlaunch shakedown; Mix of mature and advanced technology
  - --"Clementine"-style mission ops personnel requirements
  - -- Launch one per year
- Obviously miniaturizing and reducing mission scope lets us do science we otherwise might not be able to afford.
  - --But this approach alone would eventually reach point of diminishing returns. We could perform missions, but they would not really be scientifically valuable.
- The first real solution is what we're planning for 2000 and beyond. Spacecraft that have advances in many key technologies. Typical planetary mission post-2000:
  - --Cost =\$tens of millions

- -- Mass = tens of kilograms
- --Multiple spacecraft per small ELV
- --Short development time, advanced technology systems
- --Build/integrate on cleanroom lab bench
- --Highly autonomous

## Closer Look: post-2000 vs. flagship class

- Remember that our goal is not just to make planetary spacecraft smaller and cheaper to launch. We must give them capabilities equal to or better than the probes that have produced such great science in the past.
- Revolutionary advances in spacecraft technologies affect more than just science capabilities. Impact spacecraft from assembly thru end-of-mission.
- Example: Post-2000 fabrication/test techniques vs. Galileo/Cassini:
  - --Assembled in cleanroom lab or bench vs. large "factory" facility
  - --Glove-box like environment vs. large lifting cranes, assembly stands
  - --Entire systems fabricated as MEMS chips vs. black box systems wired together

- --Rapid software development using DoD/commercial methods vs. custom, one-of-a kind flight software.
  --Tens of people vs. hundreds for Flagship-class.
- These are the type of advances that will let us produce and launch an armada of spacecraft for the most ambitious exploration of solar system ever. Eventually, we plan to launch at the rate of one per month. Many, many more opportunities for PIs than today; you won't spend your whole career on one project.
- Example: Post-2000 mission ops vs. Magellan
  - --<30 people vs. Magellan's 300 (at peak)
    --Autonomous optical navigation using
    pre-loaded star/planet/asteroid maps vs.
    radio-based navigation instructions
    --Onboard health, status, fault
    monitoring vs. ground-based monitoring
    --Event-driven, goal-directed spacecraft
    sequencing vs. time-based, open-loop.
- Making the spacecraft as autonomous as possible obviously cuts cost, but also makes for more efficient operations. PIs also would have more direct relationship with their

science instruments because the ground and space infrastructure is essentially transparent.

- Example: Science at Triton. Compare capabilities of Planetary Integrated Camera Spectrometer (PICS) being developed for NASA's future planetary spacecraft vs. Voyager scan platform.
  - --PICS, 5 kg vs. Voyager 100 kg
  - --PICS, 1.5w power vs. Voyager 70w
  - --PICS visible imaging 1000 times more sensitive.
  - --PICS sensitivity allows both UV and IR imaging spectrometry. Could map cold body like Triton; Voyager could not.
  - --PICS spectral coverage 2-3 times greater, less geometric distortion.
- As planetary scientists, imagine what you could do with such capabilities. We will be able to optimize the spacecraft instruments for the particular conditions of the body to be studied.
- Example: Communications capability for post-2000 vs. "Flagship" class. Uses Multi-Chip Modules with 3-D stacking and MEMS:
  - -- Mass 2 kg vs. Cassini, 6 kg.

- --100 to 1 data compression vs. <30 to 1 for Galileo
- --Eventually, optical communications system would allow 20 gb data streams—

  100 times current capabilities
- Such revolutions in data handling would let us deploy a constellation of small, widelyspaced platforms that would function as a giant "virtual" spacecraft.
  - --One potential application: interferometry to find Earthlike extrasolar planets.
- Advanced microspacecraft technologies (typified by "New Millennium" approach) allow orders of magnitude reductions in mass & cost. Still real "breakthrough" science requires still another leap forward to "spacecraft on a chip."
- Ultimate goal is to incorporate innovative architectures and microdevices to give us capabilities we don't have today.
- Example of technologies/architectures:
  - --MEMS
  - --VLSI circuitry
  - --High-energy density batteries
  - -- Integrated antenna

- Result is a 100g spacecraft-on-a-chip: weighs less than a McDonald's quarter-pounder.
- Deploy fleets of these spacecraft from carrier vehicle. Potential missions:
  - --Unprecedented accuracy in measuring spatial/temporal variations in planetary magnetic fields; NASA/ESA Cluster is more expensive, less capable.
  - --Much more detailed measurements of ionospheres, solar wind
  - --Global climatology
  - --Global seismology and geology
- These points are particularly important because there are two drivers for our planetary science program: pure science and the need to perform robotic precursor missions before deciding on our next human spaceflight goal.
- Four possible destinations and potential resources that robotic missions will look for: (See "Resources Available" charts from Code SL)
- Webster's Dictionary defines "revolution" as "a sudden or radical change in a

situation." That's what we're after at NASA, a true technological revolution. A "sudden, radical change" in what we're asking from technology. We're going to use state-of-theart technology to do incredible, amazing things, and we're going to do it "better, faster, cheaper" than ever before.